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Health and Environmental Effects Profile for Direct Lightfast Blue

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16. ABSTRACT

The Health and Environmental Effects Profile for Direct Lightfast Blue was prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA) and to provide health-related limits for emergency actions under Section 101 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Both published literature and information obtained from Agency program office files were evaluated as they pertained to potential human health, aquatic life and environmental effects of hazardous waste constituents.

Quantitative estimates have been presented provided sufficient data are available. Existing data are insufficient to determine a Reference Dose (RfD) or a carcinogenic potency factor for Direct Lightfast Blue.

The Reportable Quantity (RQ) value of 1, 10, 100, 1000 or 5000 pounds is used to determine the quantity of a hazardous substance for which notification is required in the event of a release as specified by CERCLA based on chronic toxicity. Existing data are insufficient to determine an RQ value.

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HEALTH AND ENVIRONMENTAL EFFECTS PROFILE FOR DIRECT LIGHTFAST BLUE

ENVIRONMENTAL CRITERIA AND ASSESSMENT OFFICE
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This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

Health and Environmental Effects Profiles (HEEPs) are prepared for the Office of Solid Waste and Emergency Response by the Office of Health and Environmental Assessment. The HEEPs are intended to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA), as well as to provide health-related limits for emergency actions under Section 101 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Both published literature and information obtained from Agency program office files are evaluated as they pertain to potential human health, aquatic life and environmental effects of hazardous waste constituents. The literature searched and the dates of the searches are included in the section titled "Appendix: Literature Searched." The literature search material is current through November, 1985.

Quantitative estimates are presented provided sufficient data are available. For systemic toxicants, these include Reference doses (RfDs) for chronic exposures. An RfD is defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect. In the case of suspected carcinogens, RfDs are not estimated in this document series. Instead, a carcinogenic potency factor of q_1^* is provided. These potency estimates are derived for both oral and inhalation exposures where possible. In addition, unit risk estimates for air and drinking water are presented based on inhalation and oral data, respectively.

Reportable quantities (RQs) based on both chronic toxicity and carcinogenicity are derived. The RQ is used to determine the quantity of a hazardous substance for which notification is required in the event of a release as specified under CERCLA. These two RQs (chronic toxicity and carcinogenicity) represent two of six scores developed (the remaining four reflect ignitability, reactivity, aquatic toxicity and acute mammalian toxicity).

The first draft of this document was prepared by Syracuse Research Corporation under EPA Contract No. 68-03-3228. The document was subsequently revised after reviews by staff within the Office of Health and Environmental Assessment: Carcinogen Assessment Group, Reproductive Effects Assessment Group, Exposure Assessment Group, and the Environmental Criteria and Assessment Office in Cincinnati.

The HEEPs will become part of the EPA RCRA and CERCLA dockets.

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EXECUTIVE SUMMARY

Direct Lightfast Blue is a common name for the commercial azo dye Direct Blue 71, which is produced by the diazotization of 3-amino-1,5-naphthalene-disulfonic acid with 1-naphthylamine and subsequent coupling reactions with 1-naphthylamine-7-sulfonic acid and 2-amino-5-naphthol-7-sulfonic acid (Society of Dyers and Colourists, 1971a). It is soluble in water but insoluble in most nonpolar organic solvents. It can be used to dye, stain or print cellulose, silk, leather, paper, casein-formaldehyde plastics, cellophane, cotton, wool or nylon and to color soap (Society of Dyers and Colourists, 1971a). In 1973, four U.S. manufacturers produced 0.131 million pounds of Direct Lightfast Blue (USITC, 1975), but only one U.S. manufacturer reported production in 1984 (USITC, 1985). Three U.S. companies currently market Direct Lightfast Blue under various tradenames (AATCC, 1985).

The only available data specific to the environmental fate of Direct Lightfast Blue is a study by which Wuhrmann et al. (1980) found that it can be reduced microbially by a strain of Bacillus cereus isolated from soil. If released to water, Direct Lightfast Blue may be susceptible to significant adsorption because dyestuffs by their substantive nature (ability to be exhaustively deposited to fibers from aqueous baths) are likely to be adsorbed onto both sewage works sludge and silts and sediment of rivers and lakes (Brown and Laboureur, 1983). Removal of adsorbed Direct Lightfast Blue may occur by anaerobic biodegradation since a number of azo dyes have been found to be substantially biodegraded under anaerobic conditions (Brown and Laboureur, 1983). In general, direct dyes are expected to be relatively stable to direct photolysis in natural waters (Porter, 1973), but humic materials in natural water have been found to strongly accelerate the indirect photodecomposition of some azo dyes (Haag and Mill, 1985).

Hydrolysis, volatilization and bioconcentration are not expected to be significant; indirect photolysis, microbial degradation and adsorption are the important fate processes in water. If released to the atmosphere, Direct Lightfast Blue will probably be associated with particulate matter and dusts that are subject to wet and dry deposition. Some of it may be removed by reaction with atmospheric HO radical. If released to soil, Direct Lightfast Blue may not leach significantly, since dyestuffs are susceptible to significant adsorption. Microbial degradation may occur in soil. Photodegradation on soil surfaces is possible, but is expected to be insignificant beyond the surface layer.

Occupational exposure to Direct Lightfast Blue occurs during its production and its use in dyeing. Wastewater effluents are probably the major source of release to the environment. Ambient monitoring data could not be located in the available literature as cited in the Appendix.

Pertinent data regarding aquatic toxicity, pharmacokinetics, carcinogenicity, mutagenicity, developmental and reproductive effects, chronic, subchronic or acute toxicity and biochemical effects of Direct Lightfast Blue could not be located in the available literature as cited in the Appendix. While confirming studies on animal test systems is not available, a hypothesis that the azo component of the dye may be reducible to α- or ß-naphthalamine or benzidene provide a reason for concern about the possible carcinogenic potential.

The lack of data on the health effects of Direct Lightfast Blue precludes derivation of an RfD, q_1^*, RQ and F factor either directly or by analogy. In terms of the available evidence for carcinogenicity, Direct Lightfast Blue was classified as a EPA Group D chemical (U.S. EPA, 1986b);

that is, data for carcinogenicity are inadequate for public health purposes. A cautionary approach to exposure would be prudent in view of the hypothesis that biochemical reduction in humans may produce products that have known human carcinogenic potential.

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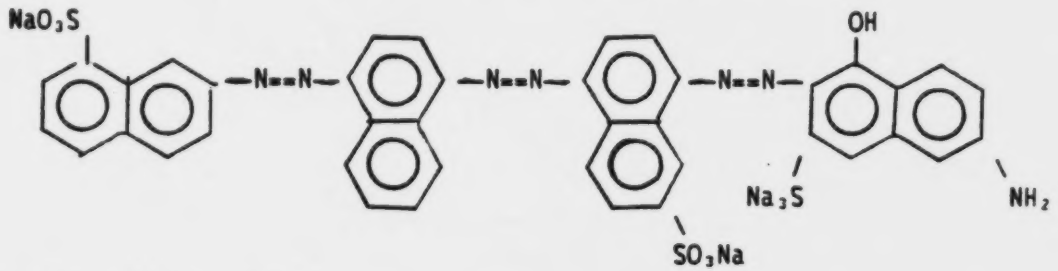
LIST OF ABBREVIATIONS

ADI	Acceptable daily intake
CAS	Chemical Abstract Service
K_{ow}	Octanol/water partition coefficient
ppm	Parts per million
RQ	Reportable quantity

1. INTRODUCTION

1.1. STRUCTURE AND CAS NUMBER

Direct Lightfast Blue is commonly referred to as Direct Blue 71. The Colour Index reference number is C.I. 34140 (Society of Dyers and Colourists, 1971a). The current CAS designation for Direct Lightfast Blue is 1,5-naphthalenedisulfonic acid, 3-[(4-((4-((6-amino-1-hydroxy-3-sulfo-2-naphthalenyl)azo)-6-sulfo-1-naphthalenyl)azo)-1-naphthenyl)azo], tetrasodium salt. Direct Blue 71 is currently marketed in the United States under the tradenames, Amidine Fast Blue FFB (John Campbell & Co.), Intralite Blue FFC Conc., FFC Ex. Conc. (Crampton & Knowles Corp.) and Orcolitefast Blue FFC (Organic Chem. Corp.) (AATCC, 1985). The structure, empirical formula and CAS Registry number for Direct Lightfast Blue are as follows:



Molecular weight: 1034

Empirical formula: $C_{40}H_{27}N_7O_{13}S_4Na_4$

CAS Registry number: 4399-55-7

1.2. PHYSICAL AND CHEMICAL PROPERTIES

Direct Lightfast Blue is soluble in water (forming a bright blue solution), slightly soluble in ethylene glycol monoethyl ether, very slightly soluble in ethanol and insoluble in most other organic solvents (Society of Dyers and Colourists, 1971a). All direct dyes are water soluble and form anions by dissociation (Kuehni et al., 1979). In aqueous solution, the molecules of direct dyestuffs are linked by hydrogen bonds forming

larger agglomerates or coloidal solutions, which reduces their solubility and promotes deposition on cellulosic fibers. The structure of these agglomerates allows firm linkage to the cellulose molecule by multiple hydrogen bonds (Kuehni et al., 1979).

Physical properties such as melting point, boiling point, vapor pressure, density and log K_{ow} could not be located in the available literature. Lack of appropriate fragment values precluded the computer calculation of log K_{ow} (U.S. EPA, 1986a). The air conversion factor for Direct Lightfast Blue is 1 ppm = 43.0 mg/m³.

The manufacture and testing of Direct Lightfast Blue probably does not conform to rigid chemical specifications, and its composition may vary in order to meet the shade and intensity requirements.

1.3. PRODUCTION DATA

Direct Lightfast Blue (C.I. 34140) is produced by coupling 3-amino-1,5-naphthalenedisulfonic acid to 1-naphthylamine followed by coupling to 1-naphthylamine-7-sulfonic acid, which is finally coupled to 2-amino-5-naphthol-7-sulfonic acid under alkaline conditions (Society of Dyers and Colourists, 1971a).

In 1973, four U.S. companies produced 0.131 million pounds of Direct Lightfast Blue (USITC, 1975), the most recent production figure available. In 1984, Crampton & Knowles Corp. was reportedly the only U.S. producer of Direct Lightfast Blue (USITC, 1985). U.S. companies that currently market the dye are listed in Section 1.1. The production and import data available from the public portion of the TSCA production file for 1977 are listed in Table 1-1.

TABLE 1-1

Direct Lightfast Blue Production Data for 1977*

Producer/Location	Manfacturer or Importer	Production Range
Fabricolor Inc. Paterson, NJ	manufacturer	none
Ugine Kuhlmann of America Paramus, NJ	importer	confidential
L & R Dyestuffs Corp. Clifton, NJ	importer	none
Allied Chemical Morristown, NJ	importer	none
Atlantic Chemical Corp. Nutley, NJ	importer	confidential
Montedison USA New York, NY	importer	none

*Source: U.S. EPA, 1977

Import of Direct Lightfast Blue through principal U.S. customs districts in recent years has been reported as follows (USITC, 1981, 1982, 1983, 1984):

Year	Import Volume (pounds)
1983	2480
1982	2313
1981	1000
1980	4253

1.4. USE DATA

Direct Lightfast Blue is a dye that can be used to dye cellulose, silk, leather, paper, casein-formaldehyde plastics and cellophane; stain silk, cotton, wood and nylon; print cellulose; and color soap (Society of Dyers and Colourists, 1971b).

1.5. SUMMARY

Direct Lightfast Blue is a common name for the commercial azo dye Direct Blue 71, which is produced by the diazotization of 3-amino-1,5-naphthalene-disulfonic acid with 1-naphthylamine and subsequent coupling reactions with 1-naphthylamine-7-sulfonic acid and 2-amino-5-naphthol-7-sulfonic acid (Society of Dyers and Colourists, 1971a). It is soluble in water but insoluble in most nonpolar organic solvents. It can be used to dye, stain or print cellulose, silk, leather, paper, casein-formaldehyde plastics, cellophane, cotton, wool or nylon and to color soap (Society of Dyers and Colourists, 1971a). In 1973, four U.S. manufacturers produced 0.131 million pounds of Direct Lightfast Blue (USITC, 1975), but only one U.S. manufacturer reported production in 1984 (USITC, 1985). Three U.S. companies currently market Direct Lightfast Blue under various tradenames (AATCC, 1985).

2. ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

2.1. WATER

2.1.1. Hydrolysis. Experimental hydrolysis data could not be located in the available literature; however, since Direct Lightfast Blue does not contain functional groups that are readily susceptible to environmental hydrolysis, hydrolysis is not expected to be environmentally significant.

2.1.2. Oxidation/Reduction. Specific experimental oxidation and reduction data could not be located in the available literature. Takemura et al. (1965) reported that bubbling of H_2S through a pure azo-dye solution yields aromatic amines and suggested that azo dyes in wastewater may be reduced at the azo linkage (by H_2S or SO_2 in the water) to form intermediates, such as benzidine or naphthylamine, from which the dye was produced. A water system receiving dyes, however, would have to be very polluted and the environment has to be reducing for this reduction reaction to proceed.

2.1.3. Photolysis. Porter (1973) examined the photodegradation rate in aqueous solution of 8 direct dyes and 12 other azo dyes in artificial light and one direct dye and one acid dye in natural sunlight. Based on the experimental results, the author concluded that direct dyes are relatively stable to direct photolysis in natural waters. Although Direct Lightfast Blue was not one of the dyes studied, its structure is similar to several dyes that were tested.

Haag and Mill (1985) examined the aqueous photodegradation rate of 15 azo dyes by simulated or natural sunlight. Potentially significant direct photolysis was observed for some dyes; however, humic materials in natural water were found to strongly accelerate the photodecomposition rate of all the dyes. Therefore, indirect photolysis may be an important removal mechanism for azo dyes in water.

2.1.4. Microbial Degradation. Wuhrmann et al. (1980) found that a strain of Bacillus cereus isolated from soil was able to reduce Direct Lightfast Blue and other azo dyes under anoxic conditions. Other microbial data specific to Direct Lightfast Blue were not found in the available literature.

Brown and Laboureur (1983) reported that a number of azo dyes were substantially biodegraded under anaerobic test conditions and suggested that the breakdown of dyestuffs in the environment may be initiated under anaerobic conditions.

2.1.5. Volatilization. Experimental volatilization data could not be located in the available literature. Direct Lightfast Blue is soluble in water (Society of Dyers and Colourists, 1971a) and is expected to have a relatively low vapor pressure, based on its chemical structure, which would predict a relatively small Henry's Law constant. Therefore, volatilization from water is not expected to occur in the environment.

2.1.6. Adsorption. Experimental adsorption data specific to Direct Lightfast Blue could not be located in the available literature. Dyestuffs by their substantive nature (ability to be exhaustively deposited to fibers from aqueous baths), however, are likely to be adsorbed onto both sewage works sludge and silts and sediments of rivers and lakes (Brown and Laboureur, 1983). In conventional biological waste treatment systems, soluble dyes are known to be adsorbed onto sludge (Porter, 1973).

2.1.7. Bioconcentration. Experimental bioconcentration data could not be located in the available literature.

The presence of Direct Lightfast Blue in the atmosphere is most likely to be associated with particulate matter and dusts, especially from atmospheric effluents resulting from production and use. These particulate matter and dusts are subject to wet and dry deposition. Since aromatic amines readily react with HO radical in the atmosphere (Atkinson, 1985),

this dye may be removed significantly from the atmosphere by HO radical reaction.

2.3. SOIL

Pertinent experimental data regarding the fate of Direct Lightfast Blue in soil could not be located in the available literature as cited in the Appendix. Chemical degradation may not significantly occur in soil since dyes, in general, are resistant to oxidative degradation (Porter, 1973) and hydrolysis is not expected to be environmentally significant. If significant chemical transformation of Direct Lightfast Blue is to occur in soil, microbial degradation may be the environmental fate process involved. Wuhrmann et al. (1980) found that a strain of Bacillus cereus isolated from soil was able to reduce Direct Lightfast Blue and other azo dyes under anoxic conditions. Additionally, a number of azo dyes have been shown to be susceptible to anaerobic biodegradation (Brown and Laboureur, 1983). Photodegradation on soil surfaces may be possible.

Since Direct Lightfast Blue is water soluble (Society of Dyers and Colourists, 1971a), leaching in soil might be expected; however, the substantive nature of dyestuffs (Brown and Laboureur, 1983), including the direct dyes (Kuehni et al., 1979), indicates that significant adsorption to soil may occur. Therefore, significant leaching in soil may not occur.

2.4. SUMMARY

The only available data regarding the environmental fate of Direct Lightfast Blue was a study that found that it can be reduced microbially by a strain of Bacillus cereus isolated from soil (Wuhrmann et al., 1980). If released to water, Direct Lightfast Blue may be susceptible to significant adsorption because dyestuffs by their substantive nature (ability to be exhaustively deposited to fibers from aqueous baths) are likely to be adsorbed onto both sewage works sludge and silts and sediment of rivers and

lakes (Brown and Laboureur, 1983). Removal of adsorbed Direct Lightfast Blue may occur by anaerobic biodegradation since a number of azo dyes have been found to be substantially biodegraded under anaerobic conditions (Brown and Laboureur, 1983). In general, direct dyes are expected to be relatively stable to direct photolysis in natural waters (Porter, 1973), but humic materials in natural water have been found to strongly accelerate the indirect photodecomposition of some azo dyes (Haag and Mill, 1985). Hydrolysis and volatilization are not expected to be significant; indirect photolysis, microbial degradation and adsorption are the important fate processes in water. If released to the atmosphere, Direct Lightfast Blue will probably be associated with particulate matter and dusts that are subject to wet and dry deposition. Some of it may be removed by reaction with atmospheric HO radical. If released to soil, Direct Lightfast Blue may not leach significantly, since dyestuffs are susceptible to significant adsorption. Microbial degradation may occur in soil. Photodegradation on soil surfaces is possible, but is expected to be insignificant beyond the surface layer.

3. EXPOSURE

Direct Lightfast Blue has not been reported to occur in nature; therefore, exposure from natural sources is not expected to occur. Occupational exposure to Direct Lightfast Blue occurs during its production and its use for the dyeing of various products. Likely routes of exposure are inhalation of particulates and dermal exposure.

3.1. WATER

Pertinent monitoring data for Direct Lightfast Blue could not be located in the available literature as cited in the Appendix. For the organic dye industry, in general, it has been estimated that ~90% of the dye during use ends up on the fabric, while 10% is lost to wastewater effluents (Porter, 1973; Brown et al., 1981). Losses of dyes to wastewater effluents during manufacture were estimated to be 1-2% (Brown et al., 1981). Waste streams from dye manufacture contain dissolved inorganic salts and small amounts of dye and dye intermediate (Steadman et al., 1977). Wastewater effluents are therefore the major source of release to water. The efficiency of wastewater treatment operations will determine the amount of dye that reaches natural waters.

Release of dye from textile fabrics may occur from commercial or consumer washing; however, dyes in most finished products are considered to be essentially "fast" (they do not migrate or wash out) (Jones, 1979). Various after-treatments are commonly applied to fabrics dyed with direct dyes to improve the wetfastness quality (Kuehni et al., 1979).

3.2. FOOD

Pertinent data regarding exposure to Direct Lightfast Blue through food could not be located in the available literature as cited in the Appendix.

3.3. INHALATION

No ambient or occupational air monitoring data specific to Direct Lightfast Blue were located in the available literature as cited in the Appendix.

Ambient atmospheric emissions may occur from ventilation effluents at production and use sites. In addition, air effluents from production operations, such as spray drying, may be sources of release. Particulate emissions from these sources are usually filtered at the plant site, which should reduce significantly the amount of particulate matter actually reaching the ambient atmosphere.

3.4. DERMAL

Pertinent monitoring data could not be located in the available literature as cited in the Appendix. The general public is exposed mainly to finished dyes after they have been applied to the product; however, there is little chance of dyes coming off in perspiration, saliva or washings if label instructions are followed (Jones, 1979).

3.5. SUMMARY

Occupational exposure to Direct Lightfast Blue occurs during its production and its use in dyeing. Wastewater effluents are probably the major source of release to the environment. No ambient monitoring data were found in the available literature as cited in the Appendix.

4. PHARMACOKINETICS

Pertinent data regarding the absorption, distribution, metabolism and excretion of Direct Lightfast Blue could not be located in the available literature as cited in the Appendix.

5. EFFECTS

Pertinent data regarding the carcinogenicity, mutagenicity, developmental and reproductive effects, chronic, subchronic or acute toxicity and biochemical effects of Direct Lightfast Blue could not be located in the available literature as cited in the Appendix.

6. AQUATIC TOXICITY

Pertinent data regarding toxicity of Direct Lightfast Blue to aquatic organisms could not be located in the available literature as cited in the Appendix.

7. EXISTING GUIDELINES AND STANDARDS

7.1. HUMAN

Pertinent guidelines and standards, including EPA ambient water and air quality criteria, drinking water standards, FAO/WHO ADIs, EPA or FDA tolerances for raw agricultural commodities or foods, and ACGIH, NIOSH or OSHA occupational exposure limits could not be located in the available literature as cited in the Appendix.

7.2. AQUATIC

Guidelines and standards for the protection of aquatic biota from the effects of Direct Lightfast Blue could not be located in the available literature as cited in the Appendix.

8. RISK ASSESSMENT

The total lack of data on the health effects of Direct Lightfast Blue precludes derivation of an RfD or q_1^* either directly or by analogy. However, the possibility exists that the azo component of the dye has the potential to be degraded in a reducing environment (the gut) to substances that are clearly shown to have a carcinogenic potential of Group C, B_2 and A (α- and β-naphthalamine benzidene). Since this degradation has not been confimed in annual test systems, the possibility can only be hypothesized. A cautionary public health approach to limit exposure would be prudent in view of the hypothesis.

9. REPORTABLE QUANTITIES

9.1. REPORTABLE QUANTITY (RQ) BASED ON CHRONIC TOXICITY

Data are not sufficient for deriving an RQ.

9.2. WEIGHT OF EVIDENCE AND POTENCY FACTOR ($F=1/ED_{10}$) FOR CARCINOGENICITY

Data are not sufficient for deriving an F factor. Direct Lightfast Blue is best classified as an EPA Group D chemical (U.S. EPA, 1986b), since no "confirming" data regarding the carcinogenicity of this chemical were available. However, the chemical makeup of the dye and the potential for biochemical reduction in the human gut suggests a hypothesis whereby the azo component of the dye would yield α- or β-naphthalamines/benzidene. These degradation products have shown possibly probable/definite human carcinogenic potential, e.g., EPA group B_2 and A, respectively. A confirmation of the hypothesis would be required before a higher weight of evidence classification would be warranted. For public health purposes however, a cautionary approach would be prudent in view of the degradation hypothesis.

Direct Lightfast Blue

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USITC (U.S. International Trade Commission). 1985. Synthetic Organic Chemicals. U.S. Production and Sales, 1984. USITC Publ. 1745, Washington, DD. p. 66.

Wuhrmann, K., K. Mechsner and T. Kappeler. 1980. Investigation of rate-determining factors in the microbial reduction of azo dyes. Eur. J. Appl. Microbiol. Biotechnol. 9(4): 325-38. [CA 95(5):38494p]

APPENDIX

LITERATURE SEARCHED

This profile is based on data identified by computerized literature searches of the following:

GLOBAL
TSCATS
CASR online (U.S. EPA Chemical Activities Status Report)
CAS online STN International
TOXLINE
TOXBACK 76
TOXBACK 65
RTECS
OHM TADS
STORET
SRC Environmental Fate Data Bases
SANSS
AQUIRE
TSCAPP
NTIS
Federal Register

These searches were conducted in April, 1986. In addition, hand searches were made of Chemical Abstracts (Collective Indices 6 and 7), and the following secondary sources were reviewed:

ACGIH (American Conference of Governmental Industrial Hygienists). 1986. Documentation of the Threshold Limit Values and Biological Exposure Indices, 5th ed. Cincinnati, OH.

ACGIH (American Conference of Governmental Industrial Hygienists). 1985-1986. TLVs: Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1985-1986. Cincinnati, OH. 114 p.

Clayton, G.D. and F.E. Clayton, Ed. 1981. Patty's Industrial Hygiene and Toxicology, 3rd rev. ed., Vol. 2A. John Wiley and Sons, NY. 2878 p.

Clayton, G.D. and F.E. Clayton, Ed. 1981. Patty's Industrial Hygiene and Toxicology, 3rd rev. ed., Vol. 2B. John Wiley and Sons, NY. p. 2879-3816.

Clayton, G.D. and F.E. Clayton, Ed. 1982. Patty's Industrial Hygiene and Toxicology, 3rd rev. ed., Vol. 2C. John Wiley and Sons, NY. p. 3817-5112.

Grayson, M. and D. Eckroth, Ed. 1978-1983. Kirk-Othmer Encyclopedia of Chemical Technology, 3rd ed. John Wiley and Sons, NY. 23 Volumes.

Hamilton, A. and H.L. Hardy. 1974. Industrial Toxicology, 3rd ed. Publishing Sciences Group, Inc., Littleton, MA. 575 p.

IARC (International Agency for Research on Cancer). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans. WHO, IARC, Lyons, France.

ITII (International Technical Information Institute). 1982. Toxic and Hazardous Industrial Chemicals Safety Manual for Handling and Disposal with Toxicity and Hazard Data. ITII, Tokyo, Japan. 700 p.

Jaber, H.M., W.R. Mabey, S.T. Liu, T.W. Chow and H.L. Johnson. 1984. Data aquisition for environmental transport and fate screening for compounds of interest in the Office of Solid Waste. EPA 600/6-84-010. NTIS PB84-243906. SRI International, Menlo Park, CA.

NTP (National Toxicology Program). 1986. Toxicology Research and Testing Program. Chemicals on Standard Protocol. Management Status.

Ouellette, R.P. and J.A. King. 1977. Chemical Week Pesticide Register. McGraw-Hill Book Co., NY.

Sax, N.I. 1979. Dangerous Properties of Industrial Materials, 5th ed. Van Nostrand Reinhold Co., NY.

SRI (Stanford Research Institute). 1984. Directory of Chemical Producers. Menlo Park, CA.

U.S. EPA. 1985. Status Report on Rebuttable Presumption Against Registration (RPAR) or Special Review Process. Registration Standards and the Data Call in Programs. Office of Pesticide Programs, Washington, DC.

U.S. EPA. 1985. CSB Existing Chemical Assessment Tracking System. Name and CAS Number Ordered Indexes. Office of Toxic Substances, Washington, DC.

USITC (U.S. International Trade Commission). 1985. Synthetic Organic Chemicals. U.S. Production and Sales, 1984, USITC Publ. 1745, Washington, DC.

Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals, 2nd ed. Van Nostrand Reinhold Co., NY.

Windholz, M., Ed. 1983. The Merck Index, 10th ed. Merck and Co., Inc., Rahway, NJ.

Worthing, C.R. and S.B. Walker, Ed. 1983. The Pesticide Manual. British Crop Protection Council. 695 p.

In addition, approximately 30 compendia of aquatic toxicity data were reviewed, including the following:

Battelle's Columbus Laboratories. 1971. Water Quality Criteria Data Book. Volume 3. Effects of Chemicals on Aquatic Life. Selected Data from the Literature through 1968. Prepared for the U.S. EPA under Contract No. 68-01-0007. Washington, DC.

Johnson, W.W. and M.T. Finley. 1980. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Summaries of Toxicity Tests Conducted at Columbia National Fisheries Research Laboratory. 1965-1978. U.S. Dept. Interior, Fish and Wildlife Serv. Res. Publ. 137, Washington, DC.

McKee, J.E. and H.W. Wolf. 1963. Water Quality Criteria, 2nd ed. Prepared for the Resources Agency of California, State Water Quality Control Board. Publ. No. 3-A.

Pimental, D. 1971. Ecological Effects of Pesticides on Non-Target Species. Prepared for the U.S. EPA, Washington, DC. PB-269605.

Schneider, B.A. 1979. Toxicology Handbook. Mammalian and Aquatic Data. Book 1: Toxicology Data. Office of Pesticide Programs, U.S. EPA, Washington, DC. EPA 540/9-79-003. NTIS PB 80-196876.